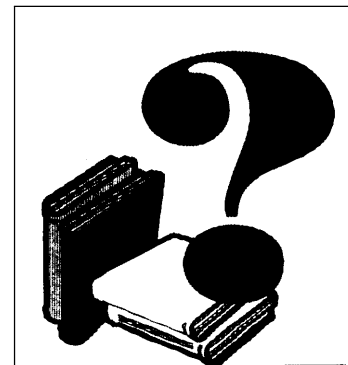


Summary 1

In the past two decades, studies of energy technologies increasingly have focused on quantifying environmental effects. In particular, many studies have attempted to estimate the *environmental cost* of different electricity generating technologies—the monetary value of the environmental effects—so that environmental concerns can be incorporated more easily into public and private decisionmaking.

These environmental cost studies have attracted the attention of a variety of legislators and regulators. Although few measures have been enacted with the intent of directly passing environmental costs onto consumers, several state and federal actions require that these costs be estimated and considered by utilities. For example, 29 states require utilities to consider environmental costs in some way when they choose among electricity supply options, and many other states are considering such measures. Several federal statutes also mandate that utilities or agencies estimate environmental costs.

Credible and accurate information about environmental costs could be a critical component of future state and federal policies. Several new studies will be released within the next year (see chapter 2 for details), and these new studies, as well as previously completed studies, could help federal policy makers make choices about the use of current electricity technologies and the level of support warranted for new or improved technologies. They also could allow quantification of the potential benefits associated with electricity technologies that have fewer environmental impacts (e.g., solar and wind energy) and technologies that reduce energy use (e.g., energy-efficient appliances). This is particularly important given that many of these alternative technologies currently cost more than traditional technologies.



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BOX 1-1: The OTA Report in Context

This report examines the methodology, findings, and implications of studies that estimate the environmental costs of electricity production. Specifically, it:

- explains the principles behind estimates of environmental costs and the terms used to discuss such estimates,
- summarizes and compares existing estimates of environmental costs and the methods of arriving at those estimates,
- characterizes and analyzes the reasons for differences in estimates, particularly the assumptions and values that underlie different estimates, and
- discusses challenges associated with using current estimates in policymaking.

In contrast to many other reports on environmental cost studies, this report focuses on the studies' assumptions and values. The House Committee on Science, Space, and Technology, which requested this report, asked OTA to examine the fundamental assumptions and values that underlie debates over environmental costs and to explore their implications for policymaking.

The study focuses on environmental cost estimates for electricity generation because this area has produced substantial regulatory and legislative activity. It does not consider other types of costs (e.g., government subsidies and economic effects), nor does it consider other sectors of the economy concerned with energy (e.g., transportation).¹

OTA did not attempt to make its own estimates of the environmental costs of electricity. The study's request explicitly excluded such estimates, and OTA finds that generally accepted estimates would be difficult, if not impossible, to achieve at this time.

In addition, this study does not discuss specific policy instruments. The use of specific policy instruments is largely separate from the estimation of environmental costs. Another OTA study is currently reviewing a variety of new approaches to environmental regulation.²

¹Another OTA study does examine the social costs of transportation: U.S. Congress, Office of Technology Assessment, *Saving Energy in the U.S. Transportation System*, OTA-ETI-589 (Washington, DC: U.S. Government Printing Office, July 1994).

²U.S. Congress, Office of Technology Assessment, *Rethinking Environmental Regulation* (Washington, DC: U.S. Government Printing Office, forthcoming).

SOURCE Office of Technology Assessment, 1994.

The Office of Technology Assessment (OTA) has examined several studies of the environmental costs of electricity (see box 1-1). This report reviews the studies' results, methods, and assumptions in an effort to determine whether there are generally accepted approaches to estimating environmental costs and whether the studies have converged upon similar conclusions. The report does not provide a detailed discussion of how the findings of these studies might be incorporated into policy. Where policy relevance is discussed, it is primarily from a federal perspective.

OTA concludes that no clear consensus exists on quantitative estimates of environmental costs

of electricity, or on methodologies for making those estimates. The methods of these studies, and the estimates themselves, vary widely. The differing methods and results have produced a contentious technical debate among analysts and policymakers who wish to use the results of environmental cost studies. Many of these differences can be addressed through further research and analysis. Some critical disagreements over methodology, however, mask deeper disputes over values, basic policy goals, and the intended role of environmental cost studies. It is unlikely that these disputes can be resolved by technical analysis or scientific research. Instead, these disagree-

ments are more likely to be successfully addressed through public debates in the policy arena.

This report summarizes several existing and ongoing studies, discusses several major methodological disputes and the assumptions underlying them, and attempts to characterize the different frameworks of assumptions. Understanding these frameworks can help policymakers understand both current and future studies, avoid unintentionally accepting the embedded assumptions of studies, and make the best use of the information the studies provide.

STUDIES OF ENVIRONMENTAL COSTS

Environmental cost studies usually compare the effects of several different energy sources (e.g., coal, oil, nuclear, and solar). The studies catalog the emissions from power plants (e.g., sulfur dioxide (SO₂) and carbon dioxide (CO₂)) and then estimate the costs associated with those emissions. Cost estimates can be made by either: 1) evaluating the health and environmental impacts from those emissions and estimating the monetary cost of those impacts or 2) examining the cost of currently mandated measures to control those emissions or to mitigate their effects. To estimate an energy source's total environmental cost, each study adds together the damages from all environmental effects attributed to a particular source.

OTA examined eight environmental cost studies for this report (see table 1-1). The studies were selected based on their comprehensiveness, their influence, and the extent of their methodological discussion. Two of the studies (one sponsored by the U.S. Department of Energy and one sponsored by New York State) are in progress and are expected to be completed by the end of 1994. The six other studies had been completed by 1991. There are several other recent and ongoing studies in addition to those that OTA examined in detail for this request. All of these studies are discussed in chapter 2.

On the basis of a review of the methodology and estimates of these eight studies, OTA found that:

- ^m *Cost estimates are difficult to combine or compare.* Studies use very different methods of estimating, categorizing, and reporting results. These methods are so different that in-depth comparison of quantitative results is extremely difficult. In general, only broad comparisons are possible.
- ^m *Cost estimates are variable and uncertain.* Estimates made by different studies vary greatly. For example, cost estimates for the same energy source can vary between nearly zero and a value greater than current electricity prices. All studies note that their results contain substantial uncertainty. Not all studies include explicit estimates of this uncertainty, but when uncertainty ranges are given, they are often as large or larger than the estimates themselves. At least one category of costs, those associated with global warming, is potentially large, but the costs are impossible to estimate with certainty.
- *A single category of effects often dominates the cost estimates.* The studies examined by OTA made more than 50 separate estimates of the environmental costs associated with particular energy sources. In more than 80 percent of these estimates, a single category of damages accounted for the majority of the cost estimate. In one study, for example, damages associated with SO₂ accounted for more than 60 percent of the total damages associated with one type of coal-fired power plant. This observation may facilitate the use of these studies for policymaking because dominant effects may point to areas where additional legislative or regulatory attention is warranted.

METHODS FOR VALUING ENVIRONMENTAL COSTS

Valuation is the process of taking an environmental impact (e.g., number of deaths or acres of damaged forest) and estimating a monetary value for that impact. Other phases of environmental cost studies besides valuation (e.g., estimating long-term health and ecological effects) are important and are often the focus of debate, but studies involving these other phases have been part of

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TABLE 1-1: Environmental Cost Studies Reviewed by OTA

Authors	Sponsors	Title	Date
Resources for the Future; Oak Ridge National Laboratories	U.S. Department of Energy; Commission of the European Communities	External Costs and Benefits of Fuel Cycles	(forthcoming)
RCG/Hagler, Bailly, Inc.	New York State Energy Research and Development Authority; Empire State Electric Energy Research Corp.; Electric Power Research Institute	New York State Environmental Externalities Cost Study	(forthcoming)
Richard Ottinger et al. (Pace University Center for Environmental Legal Studies)	New York State Energy Research and Development Authority; U.S. Department of Energy	Environmental Costs of Electricity	1990
Stephen Bernow et al. (Tellus Institute)	Several state energy agencies and utility regulatory bodies (Vermont, Massachusetts, California, and Rhode Island)	Valuation of Environmental Externalities for Energy Planning and Operations	1990
Paul Chernick and Emily Caverhill (PLC, Inc.)	Boston Gas Co.; filed with the Massachusetts Department of Public Utilities	The Valuation of Externalities from Energy Production, Delivery, and Use	1989
Olav Hohmeyer (Fraunhofer-Institute for Systems and Innovation Research, Germany)	Commission of the European Communities	Social Costs of Energy Consumption	1988
ECO Northwest; Biosystems Analysis; Nero and Associates	Bonneville Power Administration; U.S. Department of Energy	(Several, see chapter 2 for details)	1983-1987
Michael Shuman and Ralph Cavanagh (Natural Resources Defense Council)	Northwest Conservation Act Coalition	A Model Electric Power and Conservation Plan for the Pacific Northwest: Environmental Costs	1982

NOTE Sponsors do not necessarily endorse or agree with a study's findings, particularly in the case of government agencies. Several other studies exist. See chapter 2 for additional details.

SOURCE Office of Technology Assessment, 1994

legislative policy debates for some time. In contrast, valuation is relatively new to the policy arena and deserves special attention.

At least five valuation methods are used in current environmental cost studies. *Market valuation* uses existing market prices to estimate damages. *Contingent valuation* elicits estimates from consumers by the use of survey techniques. *Hedonic valuation* examines existing market prices to detect implicit valuation of environmental factors by consumers. *Control cost valuation* examines existing regulatory decisions to detect implicit valuation

of environmental **factors by** government regulators. *Mitigation cost valuation* examines the cost of preventing or repairing environmental damages. Details of these methods can be found in chapter 3.

Disputes over valuation methods mostly center around the utility and accuracy of different types of evidence. For example, some methods (e.g., market and hedonic valuation) draw their information from consumer choices, whereas other methods draw information from the decisions of elected and appointed government officials (e.g.,

control cost valuation). Analysts and others disagree strongly about the proper method of estimating environmental costs and about whether such valuation is even useful.

ASSUMPTIONS IN ENVIRONMENTAL COST STUDIES

To make quantitative estimates of environmental costs, studies must make a large number of assumptions. Some of these assumptions involve valuation methods, others involve how to handle uncertainty or whether currently regulated effects should be included in cost estimates. Different assumptions can include or exclude whole classes of effects, and can lead to dramatically different numerical estimates for the effects that are included.

Environmental cost studies are not the only type of study in which assumptions affect results; all quantitative analyses are conducted within a general framework of assumptions and values. Environmental cost studies, however, include a particularly large number of assumptions. Attempting to estimate environmental costs necessarily uses the results of many other, more limited, component studies—for example, studies of emissions generation, transport, and deposition; environmental impacts; risk assessment; and economic valuation. Environmental cost studies incorporate the strengths and weaknesses of these component studies. As a result, environmental cost studies face an array of vexing problems that have emerged from the past two decades of research in environmental science, social science, engineering, and economics. They generally require a larger number of assumptions, contain greater uncertainties in their results, and engender more controversy than do studies of a more limited scope.

There are no obvious criteria to use in selecting a set of best assumptions for all purposes or for all policy makers. Specific assumptions draw criticism and support from different analysts, but most are not obviously flawed. Instead, these assumptions embody different goals and values that may be more or less appropriate to different purposes and policy makers. Because no single set of as-

sumptions matches the goals and values of most parties, consensus estimates of environmental costs are not possible.

The impact of the assumptions and values implicit in different estimates is large enough that isolated quantitative estimates of environmental costs are nearly meaningless. Such estimates become meaningful only in the context of a study's assumptions and of the environmental effects that are included. This conclusion indicates that isolated quantitative estimates of environmental cost studies should not be presented as the final results of a study. This practice improperly focuses attention only on the numerical results, rather than on explaining those results in the context of the study's assumptions.

Investigating the assumptions that underlie these different estimates can help explain why the estimates differ and can also help to clarify broader debates over the environmental costs of energy. On the basis of the methodology of environmental cost studies, position papers by stakeholders, and a workshop convened for this study, OTA identified several frameworks of goals and values (see chapter 4 for details). These frameworks can be characterized by the answers to fundamental questions such as:

- *What is the goal of environmental policy?* Environmental cost studies are most frequently associated with the goal of economic efficiency. Other implicit and explicit goals assumed in environmental cost debates include equity, sustainability, and protection of health and safety.
- *What is the role of environmental cost studies in energy policy?* These studies can be used to quantify economic corrections to energy markets, facilitate compensation for environmental damages, or guide government regulation to protect health or encourage sustainability.
- *How is value determined?* Valuation can be based on consumers acting in markets, legislators and regulators acting in political systems, scientists studying ecological systems, or government officials acting in legal settings.

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Different answers to these questions lead to different assumptions about what effects to include, how to value those effects, and how to handle uncertainty. These assumptions, in turn, can lead to widely divergent estimates of the environmental costs of electricity generation. All studies make these assumptions based on frameworks of goals and values, and these frameworks are often the focus of substantial disagreement. Rather than helping to resolve political and social debates, current environmental cost studies often reflect different positions in these debates.

ROLES FOR ENVIRONMENTAL COST STUDIES IN POLICYMAKING

Given that assumptions and values are so important to the methods and results of environmental cost studies, what role can such studies serve in developing federal policy?

| Current Laws and Regulations

Several federal laws and regulations already require some examination of environmental cost. For example, consideration of environmental cost is required under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Public Law 96-501). The Clean Air Act Amendments of 1990 (Public Law 101-549) require the Environmental Protection Agency (EPA) Administrator to conduct a comprehensive analysis of the effects of the act on the public health, economy, and environment of the United States. The Energy Policy Act of 1992 (Public Law 102-486) requires the Secretary of Energy to develop a least-cost national energy strategy that considers the economic, energy, environmental, and social costs of various energy technologies.

Some pending federal legislation has a connection to environmental cost issues. For example, much of the debate over whether to elevate the EPA to cabinet-level status has concerned whether the new agency would be required to perform cost-benefit analyses of proposed regulations. Some EPA regulations directly address the environmental effects of energy, and environmental cost studies hold the promise of helping to quanti-

fy regulatory benefits. EPA conceivably could conduct or use many different types of studies of costs and benefits. Some of these studies lack the complexity of studies that assess the environmental cost of energy, but the difficulties, challenges, and opportunities presented by environmental cost studies may provide useful analogs for broader questions about the quantitative study of EPA regulations.

In addition to federal policies, many state regulatory commissions require some quantitative or qualitative use of environmental cost estimates. Nineteen states require utilities to consider quantitative estimates of environmental costs. Requirements in another 10 states and the District of Columbia mandate the use of qualitative criteria that attempt to account for environmental costs.

| Making Studies More Useful to Federal Policymakers

For federal policymakers, use of environmental cost studies offers both pitfalls and opportunities. Pitfalls include the unknowing acceptance of assumptions and values embedded within the studies' quantitative analysis. Opportunities include using environmental cost studies as a way to explore the importance of specific assumptions and as a way to gain useful insights into setting environmental priorities.

Moving Beyond Evaluation

In one way, at least, federal policymakers may find a mismatch between their own goals and those embodied in currently available studies of the environmental costs of electricity. Many of the assumptions in currently available studies stem from an emphasis on the goals of state utility commissions. In particular, these studies often assume that the important decisions involve choosing among available electricity generating technologies, rather than attempting to alter the relevant environmental effects of those technologies. Federal policy often involves the latter, through laws and regulations concerning pollution control technologies, mining and transportation safety, waste disposal, and impact mitigation.

One consequence of the existing focus on choosing among different generating technologies is that studies often report aggregate values that indicate total environmental costs. Such results are useful to state regulatory commissions that wish to affect how utilities add new generating capacity. However, they are of limited use to federal legislators and regulators, who have a wider array of policy measures available. If studies are not relevant to the design and management of electricity generating technologies, then federal policy makers may not be able to use the studies effectively or they may choose to ignore them entirely.

In contrast, if environmental cost studies present disaggregated results, then they could prove more useful to federal policy makers. They could assist legislators and regulators with setting priorities and designing efficient and effective regulatory programs. For example, if future studies analyze and report the relative importance of different effects as prominently as current studies report total environmental costs, then future studies could help support priority-setting activities in both regulatory programs and research and development activities.

Emphasizing Nonquantitative Results

Environmental cost studies often focus on what appears to be the “bottom line” —the monetary value of environmental effects. In many cases, this is the most speculative and controversial aspect of the study, and effects that are not monetized are often ignored. In contrast, focusing on the earlier components of the study (e.g., the emissions and impacts stages) would emphasize aspects that are most amenable to scientific and technical resolution.

Monetization is useful, but its very nature allows the results of environmental cost studies to be reported in a highly aggregated form. This encourages use of the results without the full understanding of the assumptions and values that underlie them. Placing greater emphasis on reporting the results of earlier phases of the analysis (e.g., emissions and impacts assessments), and on

clearly explaining the assumptions and values that underlie the estimates of monetary damages, would greatly assist the federal decisionmakers who may use the studies.

Informing Legislative Decisionmaking

At least for the near term, use of environmental cost studies on the federal level is likely to engender continued disputes over methodology and results. As is the case with current studies, much of the controversy over future studies will likely be due to fundamental differences in assumptions and the associated frameworks of goals and values, rather than specific findings of a given study. For policymakers, accepting and using the quantitative findings of a particular study of environmental costs implies accepting the goals and values embedded in that study.

Some analysts believe recent studies (e.g., DOE/EC and New York State) are converging on a common set of methods and their results should be preferred over those of other studies. In several ways, these recent studies do represent advances over older studies because they review a larger body of literature, they are often more systematic in their survey of emissions and environmental impacts, and several elements of their technical methodology are more sophisticated.

However, this methodological sophistication may be less important than the studies’ basic assumptions, many of which depend on policy goals and values that are beyond the purview of analysts. These recent studies *do* make a relatively consistent set of assumptions. For example, these studies value environmental effects using only damage cost approaches (see chapter 3) and they employ relatively high standards of proof about what emissions and impacts should be included in environmental cost estimates. However, whether these assumptions represent objectively “better” choices depends on the goals and values of policymakers who use these studies, rather than on the opinions of analysts.

Technical and methodological critiques of environmental cost studies are important, but they are not the only important critiques. A study may

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be technically excellent and still not meet the needs of Congress and of executive branch agencies. If a study's values and assumptions differ radically from those of the relevant policy makers, then they may reject the study on those grounds alone. Such an action would not be "ignoring science" but would constitute the legitimate exercise

of the policy makers' public responsibilities. In contrast, if a study's values and assumptions are made clear and match those of the relevant decisionmakers, then the study may be able to provide valuable insights of a sort that other analyses cannot.